Amendment to the Claims

In the Claims:

Please cancel Claims 1-18 and amend Claim 19 as follows:

1. – 18. (Canceled)

19. (Currently Amended) Apparatus for detecting bleeding at an internal site using ultrasound, comprising:

(a) an ultrasound transducer;

(b) a control system coupled to the ultrasound transducer to control its operation; and

(c) a tissue vibration processor that processes the ultrasound to identify naturally occurring tissue vibrations that are caused by internal bleeding and are not induced by any external device, producing a signal indicating the internal bleeding.

20. (Original) The apparatus of Claim 19, wherein the signal produced by the tissue processor localizes the internal bleeding by determining a location of the tissue vibrations.

21. (Original) The apparatus of Claim 19, wherein the signal produced by the tissue vibration processor is usable to produce a vibration image in which the tissue vibrations indicate a location of the internal bleeding.

22. (Original) The apparatus of Claim 21, further comprising a display on which the vibration image is presented, the vibration image indicating a location of the internal bleeding.

23. (Original) The apparatus of Claim 19, wherein the signal produced by the tissue vibration processor is audible and includes characteristics that indicate the internal bleeding.

24. (Original) The apparatus of Claim 19, wherein the signal produced by the tissue vibration processor is employed to provide a palpable indication of the internal bleeding.

25. (Original) The apparatus of Claim 19, wherein the tissue vibration processor comprises an application specific integrated circuit.

26. (Original) The apparatus of Claim 19, wherein the tissue vibration processor comprises a general purpose processor that executes software to identify the tissue vibrations and produce the signal.

27. (Original) The apparatus of Claim 19,wherein the tissue vibration processor determines a bleeding rate from a frequency and an amplitude of the tissue vibrations.

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28. (Original) The apparatus of Claim 19, wherein the tissue vibration processor identifies the tissue vibrations, producing a tissue vibration signal, and filters the tissue vibration signal, producing a filtered signal from which any contribution to the tissue vibration from a source other than bleeding at the internal site has been substantially minimized.

29. (Original) The apparatus of Claim 28, wherein the tissue vibration processor determines tissue vibrations at the internal site by:

(a) estimating a correlation matrix from the color-flow signal;

(b) carrying out an eigendecomposition of the correlation matrix to identify a signal subspace and a noise subspace;

(c) estimating a frequency of dominant vibration components in the signal subspace and the noise subspace; and

(d) based upon an estimate of the frequency of the dominant vibration components, determining a vibration amplitude estimate and a vibration frequency estimate, at least one of the vibration amplitude estimate and the vibration frequency estimate comprising the tissue vibration signal.

30. (Original) The apparatus of Claim 28, wherein the tissue vibration processor determines tissue vibrations at the internal site by:

(a) computing reflection coefficients from the color-flow signal;

(b) computing linear prediction filter coefficients from the reflection coefficients;

(c) estimating a power spectrum and detecting peaks in the power spectrum; and

(d) based upon an estimate of the power spectrum and the peak, determining a vibration amplitude estimate and a vibration frequency estimate, at least one of the vibration amplitude estimate and the vibration frequency estimate comprising the tissue vibration signal.

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31. (Original) The apparatus of Claim 28, wherein the tissue vibration processor determines tissue vibrations at the internal site by:

(a) estimating a mean clutter velocity from the color-flow signal, using autocorrelation;

(b) down mixing the color-flow signal with the mean clutter velocity, producing a down mixed signal;

(c) computing a phase of the down mixed signal and a mean phase of the down mixed signal;

(d) subtracting the mean phase from the phase of the down mixed signal, producing a residual phase;

(e) decomposing the residual phase into its dominant components; and

(f) applying energy and frequency thresholds to substantially suppress any contribution to the tissue vibration due to noise and blood flow, yielding an estimate of vibration amplitude and vibration frequency of tissue.

32. (Original) The apparatus of Claim 31, wherein the tissue vibration processor decomposes the residual phase by:

(a) estimating a correlation matrix from the residual phase; and

(b) performing an eigendecomposition of the correlation matrix to determine the dominant components.

33. (Original) The apparatus of Claim 28, wherein the tissue vibration processor filters the tissue vibration signal by filtering out clutter and noise at frequencies that are substantially lower than an expected frequency range of tissue vibrations corresponding to bleeding at the site.

34. (Original) The apparatus of Claim 28, wherein the tissue vibration processor filters the tissue vibration signal by filtering out clutter and noise at frequencies that are substantially higher than an expected frequency range of tissue vibrations corresponding to bleeding at the site.

35. (Original) The apparatus of Claim 19, wherein the tissue vibration processor further confirms that vibrations displayed in the vibration image correspond to bleeding at the site by placing a Doppler sample volume at a location of the tissue vibration, producing a tissue vibration spectrum.

36. (Original) The apparatus of Claim 19, wherein the display presents at least one of a vibration amplitude image and a vibration frequency image of the internal site.

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37. (Original) The apparatus of Claim 19, further comprising a B-mode processor that produces a grayscale image showing underlying anatomy of the internal site, so that the display selectively presents at least one of a B-mode image of the internal site and the tissue vibration image of the internal site, substantially in real time.

38. (Original) The apparatus of Claim 19, further comprising a color-flow processor, so that the display selectively presents at least one of a color-flow image of the internal site and the tissue vibration image of the internal site.

39. (Original) The apparatus of Claim 19, further comprising a Doppler processor.

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